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Measure of Insulation

From The Editor . . .

Everyone wants to be green these days – to be seen to be doing the right thing. However, saying it and doing it are two separate things. As Kermit the Frog said on Sesame Street – it's difficult to be green.

Alberta builders did the right thing a number of years ago when they launched the Built-Green program. This was a market-driven, industry-led initiative to promote better, more energy efficient and environmentally responsible construction. The strength of the program was its structure which made it easy for builders to participate, yet had meaningful technical criteria with mandatory performance benchmarks. This meant that minimum performance levels had to be met in order to obtain the goals.

Regrettably there has been backsliding and the program now risks moving into the green washing category. The Built Green board has decided to eliminate mandatory minimum EnerGuide rating requirements, although they will still require an EnerGuide label.

Shifting from performance requirements to just a checklist-based one does not guarantee better performing homes. The focus of a checklist is on qualitative issues that should mean a better more meaningful building, but they do not always achieve performance results.

Performance requirements are important because "green" is not just product features and recycled content. Green building with a lower environmental impact must also be energy efficient, but that can't be achieved unless there are clearly defined targets. The City of Vancouver discovered this when they introduced new code standards with the expectation of getting more energy efficient homes, with an average rating of about 80, but have found that in spite of stringent prescriptive standards, the average achieved is closer to 75.

When better-built building is promoted, third party review and minimum performance criteria lends credibility, especially when a set standard must be attained. This is what is being lost by Built-Green if they persist in removing a mandatory performance requirement.

I don't know if there's something in the water or air of Alberta, or maybe it's the influence of the oil patch that still denies that human activity is having an impact on global climate, which is at the root of the drive to greener technologies. Maybe it's a reflection of the myopic world view of the current federal government, rooted in Alberta, which is contributing to what can only be described as backsliding and softening of program standards.

No builder sets out to build badly, but just setting out an a-la-carte checklist does not guarantee better or 'greener' building. Performance targets are important, especially for voluntary programs that tout better built practices and higher quality.

Richard Kadulski,
Editor

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Measure of Insulation

Materials have varying thermal insulation properties. Some materials are good insulators while others are good heat conductors. How an assembly is put together can have significant impact on the thermal performance of the building.

Traditionally, building code requirements for residential construction have been based on the nominal value of the insulation. This was largely because, with 2x4 wood framing, the effect of wood framing on the overall performance was slight.

Today, as we build more energy efficient high performance buildings, the manner of construction and insulation becomes more important. To maximize performance, it is important to pay attention to how the assembly is put together and to minimize thermal bridging.

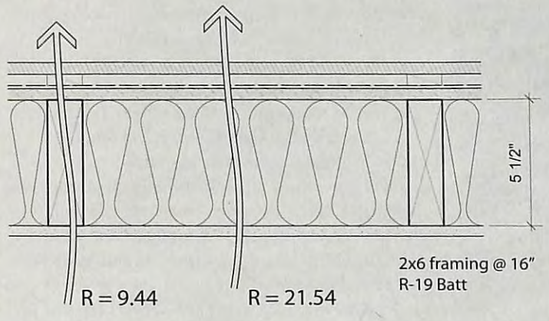
In the past, Building Codes set out insulation requirements by stipulating minimum nominal R-values for insulation, and leaving it at that. The assumption was that the thermal performance would somewhat approximate that of the insulation. However, that is far from the case. To address the discrepancies between nominal and effective R-values, building codes are developing insulation requirements based on effective R-values.

Calculation of effective R-values is straightforward, but does require some understanding of how the assemblies are put together. The biggest impact is on the walls because conventional wood frame walls have a considerable amount of framing. Just how much framing there is has been the subject of much discussion, but the most recent studies show that conventional wood framing (at 16" on centre) accounts for almost 23% of the surface of a wall.

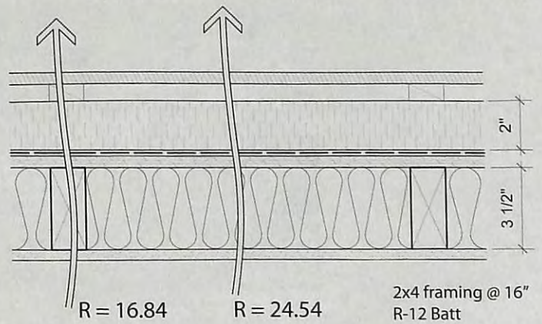
The procedure for calculating effective R-values for wood frame assemblies assumes parallel heat flows through each section, which are then averaged out proportionally. The procedure for parallel heat flow calculation is described in the ASHRAE Handbook of Fundamentals.

First, the thermal R-values of the materials in the assembly along a line that goes through the framing are calculated, then the R-values through the insulated portion. The two values are then combined in proportion to the relative areas of framing and insulation, to calculate the effective R-value using the following formula.

$$R_{effective} = \frac{100}{\frac{\%\ \text{area framing}}{\text{R-value framing}} + \frac{\%\ \text{area insulation}}{\text{R-value insulation}}}$$



Nominal R-value = 20
Effective R-value = 16.63



Nominal R-value = 22
Effective R-value = 22.2

The effective R-value of a conventional 2x6 wall can be improved by the use of rigid insulation on the exterior face of 2x4 framing.
For comparison: a 2x6 stud wall insulation with R-22 batt insulation has an effective R-value is 17.95, and with high density R-24 batts the effective R-value increases to 18.74. A 2x6 stud wall with R-22 batt insulation plus R-5 rigid insulation on the exterior has an effective R-value of R-23.82. Typical R-values for various materials are listed in the table on page 5

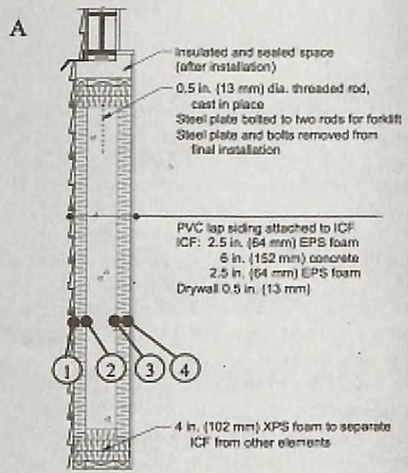
Thermal Mass Of Insulated Concrete Form Walls

Thermal storage of heat is important for low energy buildings that aim to capture solar heat. In sunny, southern climates, thermal mass is an important component of energy efficient and environmentally sensitive design. Think of the adobe buildings of the southwestern US and Mexico, or the plastered brick houses around the Mediterranean. With appropriate design of glazing and orientation, those houses are very efficient and have high solar heat gains while minimizing discomfort due to overheating.

In colder, northern regions, solar heat gains are equally important, but due to shorter days and less intense sunlight in winter, optimizing the solar gains can be a challenge. Heavy masonry construction needs to be insulated, and the mass, in order to be able to store incoming energy, must be visible to the sun. Direct copying of southern designs is not appropriate.

The mass of concrete can be an effective thermal storage element, especially if the material is being used for structural purposes.

Insulated concrete forming (ICF) technology dates back to the 1960s in Europe. However, it has only caught on in North America in the last 25 years. ICFs consist of stackable formwork


A
Insulated and sealed space (after installation)
0.5 in. (13 mm) dia. threaded rod, cast in place
Steel plate bolted to two rods for forklift
Steel plate and bolts removed from final installation
PVC lap siding attached to ICF
ICF: 2.5 in. (64 mm) EPS foam
6 in. (152 mm) concrete
2.5 in. (64 mm) EPS foam
Drywall 0.5 in. (13 mm)
1
2
3
4
4 in. (102 mm) XPS foam to separate ICF from other elements

made of polystyrene, which is filled on site with concrete, and then remains in place to provide permanent insulation. ICF technology offers the potential to deliver good energy performance resulting from a combination of good airtightness, high R-value from the insulation and passive thermal management from the mass of the sandwiched concrete layer.

The industry has touted the benefits of thermal mass for heat storage as a selling feature. However, since the ICFs have insulation inside and outside of the concrete mass, the concrete never sees the sun to absorb solar energy. There has not been much detailed analysis and study to help us understand its actual performance in the field, and the role played by the thermal mass of the concrete in regulating heat loss from the interior.

That is why field monitoring was done in 2009-10 at the National Research Council Canada's Institute for Research in Construction (NRC-IRC). The dynamic heat transmission characteristics through ICF wall assemblies exposed to normal outdoor weather conditions was monitored for one year.

Sensors were placed on the surface of four layers – at the outside face of the ICF, at the outside face of the concrete, on the interior side of the concrete and on the interior face of the ICF between the drywall and foam.

The air temperature in the room adjacent to the ICF was controlled at 21°C throughout the experiment, resulting in the interior surface of the ICF remaining around 17 to 18°C for most

This study was done by National Research Council of Canada's Institute for Research in Construction (NRC-IRC) in collaboration with Canada Mortgage and Housing Corporation (CMHC), Natural Resources Canada (NRCan) and the Ready Mixed Concrete Association of Ontario (RCMAO).

Field Thermal Mass Performance Of An Insulating Concrete Form (ICF) Wall *– a paper presented at the 13th Canadian Conference on Building Science and Technology, Winnipeg, May 2011 by M.M. Armstrong, H.H. Saber, W. Maref, M.Z. Rousseau, G. Ganapathy and M.C. Swinton from the National Research Council Canada*

of the winter. In March and April, solar gains to the interior of the research house caused room temperatures to rise, and subsequently interior temperature increased.

The exterior of the ICF was also affected by solar gains. The test wall faced west, so the exterior of the ICF, behind the siding, experienced temperature peaks on sunny afternoons. As a result, the ICF was exposed to exterior temperatures ranging from -22.2°C up to 35.1°C. The average concrete temperature began at 15.5°C, dropped to 2.6°C on December 19th at its coldest, and reached a peak of 20.4°C on April 5.

When the observed results are compared to a wall without thermal mass, the heat flow varies significantly with changes in outdoor temperatures, closely following daily temperature swings. With the thermal mass, peak flows for the ICF wall was reduced, dampening the daily peaks. The mass causes the ICF to respond more slowly to changes in outside temperatures.

From October to December, as the average exterior temperature dropped, so did the average temperature of the concrete. The average heat loss per day was about 5% lower due to the mass of the ICF. In January, there was only a small difference (1.3%) between the performance of the ICF and the wall without mass. In late winter and early spring, the thermal mass slowly heated up and caused more heat to be lost from the interior: an expected increase in heat loss of 6.8% in February, 3.5% in March, and 6.8% in April.

In a three-day period, between January 25 and January 29 the average outdoor temperature dropped from 3.4°C to -17°C. During this period, the expected heat flux through the wall with no mass increased proportionally from 3.9 to 9.5 W/m^2, while the measured heat flux through the ICF wall slowly increased, peaking five days later on February 3rd at 7.6 W/m^2. Similarly, the ICF is slow to respond to warming.

The monitored data confirmed that the concrete adds very little to the overall R-value of a wall assembly under steady-state conditions. Based on measurements, the steady state R-value of the ICF was R-21.4 (RSI 3.77), however, the steady-state R-value does not capture the dynamic performance of the wall and the impact of the mass of the concrete in the ICF.

During transient conditions (when there are changes in temperature) the concrete played a significant role in tempering heat loss to the exterior. The thermal mass of the concrete significantly moderated heat loss from the interior, storing the heat originating inside and releasing it later when the exterior temperature dropped. Thus, ICF walls have the potential to reduce the peak heating requirement of the furnace, and may have consequences for the sizing of mechanical equipment.

This research is on-going. Future work including the cooling season performance will be presented later.☼

Typical R-values of materials

Material	Average R-value
½" Gypsum board	0.45
7/16" OSB	0.69
Vinyl siding	0.62
Wood siding	1.02
3 ½" clay brick	0.42
8" concrete	1.0
2x6 stud	6.4
Fibreglass insulation	3.3/inch
Loose fill cellulose	3.6/inch
Extruded polystyrene	5/inch
Expanded polystyrene (beadboard)	3.6 – 4/inch
Open cell spray foam (½ pound foam)	3.6 – 3.8/inch
Closed cell spray foam (2 pound foam)	5 – 5.8/inch

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You Asked Us About
Exterior Insulation and Vapour Barriers

I am currently working on a project where we would like to insulate the building beyond Code minimum by adding 2 or more inches of rigid insulation to the exterior of the building. We have been discussing the detailing of exterior insulated walls, and it's been suggested that no vapour barrier would be required inboard of the rigid insulation.

We have been using this detail on some projects but Part 9 of the building code is quite specific that a vapour barrier is required. Can you comment on this? Will the code be changing the vapour barrier requirement in the future? Can a hygrothermal analysis be done on a detail like this determine if there will be condensation on the inside face of the foam insulation?

D.P.
Kamloops, BC

The question you raise comes up frequently. The building code requires a vapour barrier, and it must be placed on the warm side, but the code doesn't require poly, nor does it require that the vapour barrier need be directly on the interior face.

Although we're used to thinking of polyethylene as the vapour barrier, many other materials can satisfy the code requirement for a vapour barrier. Polyethylene is only one option among many. Common materials that can satisfy the requirement are listed in the table. The code also recognizes that the vapour barrier can be partway through the wall, but on the warm side of the dew point.

Extruded polystyrene insulation is a low permeance material. The interior face of two-inch thick extruded polystyrene (XPS) on an exterior wall will be warmer than the exterior face, so in most locations, the interior face of the XPS can be considered to be the vapour barrier. A table in the code (A9.25.1.2.A) sets out the ratio of outboard to inboard insulation required around the vapour impermeable materials, based on climate conditions. The code requirements are based on a careful hygrothermal analysis.

In most regions of Canada, 2" of XPS outboard is more than enough, and could be designated as the vapour barrier, thus dispensing with the need for polyethylene. However, the continuity of the air barrier in the building envelope must be maintained.

Thus installing 2 or more inches of XPS on the exterior of a 2x6 wall (with R-20 or R-22 batts or other loose-fill insulation) will not create any problems. It shouldn't be necessary to do special calculations other than to check the ratio of inside/outside insulation, and the XPS can be considered to be the vapour barrier.

Rigid insulation on the exterior of frame walls significantly increases the effective R-value of the assembly. Coming changes to the building code will be referencing effective R-values, so there will be more benefits to insulating on the exterior to achieve code compliant assemblies.

Acceptable Position of Vapour Barriers

Location of materials with low air permeance is generally not critical. However, any moisture that can migrate by diffusion or air movement can be problematic, which is why vapour diffusion must be controlled – that is why vapour barriers are required.

A rule of thumb developed in the early 1980s suggesting that the vapour barrier should not be more than 1/3 the R-value into the wall (the "1/3 – 2/3 rule"). It got everyone's attention, and has been considered as the absolute truth. However, considerable analysis has been done over the past few years so that we now know it's not such an absolute. Even the Building Code recognized this, and now has codified acceptable inboard/outboard ratios.

Moisture transfer through an assembly is not an issue if the low permeance materials are located at a point where the temperature is above the dew point of the indoor air. But as the low permeance material is moved towards the exterior there may be some concerns.

Heating Degree Days	Minimum R-value ratio of outboard to inboard
Less than 4999 DD˚C *Vancouver, Kelowna, Toronto, Montreal, Halifax*	0.20
5,000 to 5,999 DD˚C *Calgary, Edmonton, Saskatoon, Winnipeg, Quebec City*	0.30
6,000 to 6,999 DD˚C *Fort McMurray, Whitehorse*	0.40
7,000 to 7,999 DD˚C	0.50

Example of wall calculation showing thermal resistance inboard and outboard of a plane of low vapour permeance		
	Inboard	Outboard
Total R-value of assembly	R 19	R 5
Ratio	5/19 = 0.26	

The Building Code requires that a low air and vapour permeance material must be located on the warm face of the assembly, at a position where the inner surface will be warm enough for most of the heating season so there not be any accumulation of moisture.

Low perm materials, such as foam plastics can be used on the exterior – the interior face of the material could then be considered to be the vapour barrier. Thus in assemblies with multiple material layers, the vapour barrier could be somewhere within the assembly.

This has been defined by the Code as the ratio of the total thermal resistance outboard and inboard of the interior surface of the impermeable material (assuming it's permeability is not more than 60 ng/Pa.s.m^2).

The code recognizes that climatic conditions influence conditions of moisture transfer and risk of damage, so it has identified how to determine acceptable location for low permeance materials within an assembly. The table indicates the allowable limits.

National Building Code of Canada 9.25.5.2 Position of Low Permeance Materials and table A.9.25.5.1

Vapour Barrier materials	
Code definition of a vapour barrier is a material with a permeance of less than 60 ng/Pa.m^2.s	
Material	**Permeance**
6 mil polyethylene	3.4
2x4 wood stud	16
2x6 wood stud	10
Latex vapour barrier paint on drywall or open cell spray foam insulation	26 – 36
Foil-faced poly-isocyanurate (Iso-board)	4
Reinforced concrete	23
2-pound polyurethane spray foam (closed cell foam) – 2" thick	36 – 42
Extruded polystyrene insulation 2" thick	45
11 mm OSB	44
Vapour permeability fluctuates and depends on moisture content of the materials, temperatures, and thickness of material.	

You Asked Us:
About Exhausting a Dryer Through The HRV

I recently took an introductory workshop for LEED for houses. During the workshop the idea was floated of ducting the dryer exhaust through the HRV. What do you think about that idea?

This is a good question, as it does surface fairly regularly. However, I wonder about whoever raised the idea – when was the last time they did the laundry?

Simply put, exhausting a dryer into the interior or through the HRV is a dumb idea. The lint in the dryer exhaust will overwhelm the HRV filters in no time. HRV filters would need to be maintained on a very frequent basis - not something one can rely on the homeowner to do.

Just look how much lint build-up there is after one or two loads. A common source of house fires is the result of overheated dryers with plugged lint traps and exhaust vents that have not been cleaned.

The amount of energy to be recovered is small, not something worth the extra effort needed to deal with the lint issue. The assumptions used by R-2000 and EnerGuide for dryer exhaust air flow from the house is that it is equivalent to a continuous air flow of around 2.5 cfm. Not a tremendous energy penalty,

I remember many years ago Al Koehli (a retired builder, early R-2000 program manager) tried this in his own apartment – with a a series of pre-filters. It was an extremely complex installation, and not really viable.

Heat recovery from dryers in a commercial laundry is another thing, and something that should be considered.

Another idea that surfaces from time to time is the idea of venting the dyrer into the house, to humidify the house. One or two laundry loads drying into the interior on the coldest days of the winter may provide welcome humidity but for most of the year the humidity is not welcome. The moisture will be more than required, and will contribute more moisture problems than it solves.

Canadian Home Builders' Association

Technical Committee Research News

Built-Green Program Changes

At its June Board meeting, the Built-Green Canada Board of Directors approved changes to the program. It will maintain the current a-la-carte checklist, with minimum numbers of points required for each level (bronze, silver, gold and platinum).

The most contentious change is the removal of the EnerGuide (ERS) rating from the Built-Green certification, so there will no longer be a minimum number of ERS points required, although each house will still have to be labelled (which includes a blower door test). The elimination of the minimum ERS rating requirement means that relatively energy inefficient houses could still qualify for a high rating.

The consequences of this change are significant, because the removal of mandatory minimum criteria waters down the program. A house with a Gold label could easily be relatively energy inefficient. BC homebuilders have vigorously opposed to this move, so it will be interesting to see what action will be taken in BC, where Built-Green has been used with great success to promote green building initiatives and offer an alternative to stringent mandatory regulations.

Solar Hot Water Ready for Single Family Homes

New BC building regulations have been introduced for Solar Hot Water Ready.

The Solar Hot Water Ready requirement is voluntary – communities can choose to adopt the regulation. This provides consistent provisions across the province while still allowing flexibility for local governments to adopt provisions that work for their community and recognizes that not all communities will benefit from solar installations. It also is meant to support sustainable innovation in construction and allows forward-looking communities to take the lead in implementing green technologies.

To date, thirty-six communities have signed on to adopt the new building regulation that will require all new single family homes in their community to be built to accommodate future installation of a solar hot water system. The new regulation covers a significant portion of the provincial population.

The Solar Ready requirement for single-family homes is one of the many steps the Province is taking in fulfilling its commitment to embrace green technologies, reduce greenhouse gas (GHG) emissions, increase energy efficiency, and reduce costs at final solar panel installation.

Solar ready means there must be a 100 sq.ft. space (with a minimum dimension of 8'10") reserved on the roof for solar collectors, the structure must accommodate an extra load of 4.2 psf (0.2 kPa) for the added roof load of the solar system, and two straight, continuous conduit runs that extend from the area adjacent to the hot water heater up to the area designated for the solar collectors. The conduits must be accessible at both ends, be capped at both ends to prevent water and air leakage, and must have a minimum 2-inch (50 mm) inside diameter to permit future installation of insulated plumbing lines.

The thinking behind the solar ready regulations is that normally roof and wall spaces are not built with the weight and space requirements in mind for future installation of a solar domestic hot water system. By taking these aspects into consideration during the initial building phase, cost savings are expected when the homeowner elects to install a solar domestic hot water system at a later date.

The Solar Hot Water Ready requirement is expected to add about $200 to $500 to the cost of building a new home. What the regulations do not address, however, is the push back on the part of many local regulators that impose extra requirements when a solar hot water system is actually installed – including extra fees for third party engineering of the system design and extra, and more expensive system requirements such as double walled heat exchangers that lower the overall efficiency of the solar system.

The regulation became effective June 21, 2011 and will apply to building permits applied for new single family homes and new single family homes with a secondary suite.

Gas appliance Venting

Venting of high efficiency gas appliances is the subject of a recently issued Alberta Standata bulletin.

The increased use of high efficiency furnaces and hot water tanks has resulted in venting failures due to confusion of combustion and flue gas vent pipes, especially as combustion and exhaust vents may be located in close proximity. In some cases, ABS or PVC pipes intended for combustion air have ended up being installed as exhaust pipes.

ULC S636 certified pipe and fittings are recommended on all piping including combustion air to ensure vent piping meets current requirements. Vent and combustion air locations on appliances should be separately identified. Consideration must also be considered for proper glue, primer, and transition cement.

ULC S636 certified pipe and fittings are required on all plastic venting. ULC S636 certified CPVC, PPE or PVC or systems are based on the exhaust temperature of the specific appliance. ULC S636 certified PVC venting systems are typically suitable for flue gas temperatures to a maximums of 65° C, while CPVC venting systems are suitable for flue gas temperatures to a maximum of 90° C.

ULC S636 certified PPE venting systems are suitable for flue gas temperatures to a maximum of 110° C.

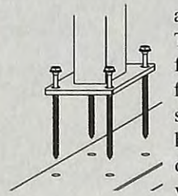
CSA-B149.1- 2010 *Natural Gas and Propane Installation Code* applies to the installation of all gas appliances. In most jurisdictions, it is ultimately the responsibility of the owner, vendor, contractor, and user to ensure that the installation and operation of appliances comply with the code.

Proper Detailing Does Matter: The Power of Water

Not paying attention to details can have devastating consequences. Guardrails for exterior decks, whether the deck is over living space or not, need to be installed properly to avoid extensive damage.

The building code considers any horizontal surface to be a roof, and requires appropriate roofing materials, whether the deck is over conditioned space or exterior decks. Thus any installed attachment should be treated the same way. We don't normally nail or fasten screws into the roof, yet far too often we see railings top mounted into the deck.

A commonly used detail is post footings that are top mounted into the deck. This is a very easy and convenient way to do it, but lousy in terms of durability. Despite the use of various caulking and mastic materials when the railings are fastened, there will still be plenty of opportunities for water to do what it normally does – flow downhill into any crack or crevice. Any mastic or caulking will deteriorate and allow water to penetrate.



It is a matter of amazement to me why guardrail manufacturers have not come up with good details to better address moisture concerns, to make it easier for installers to properly install railings.

A robust and safe installation detail is to use face-mounted brackets. Although face-mounted guardrails are commonly used today on the West coast, we still see many installers top mounting their railings. The consequences can be expensive.

Top mounted guardrail posts can be seen on one of several decks in the house.

We recently came across a situation at a very expensive, high-end home. The home had a wrap around porch that formed the roof for a portion of the lower floor. The house was not built with pressures to find cost savings so there should have been ample resources for proper detailing to be executed. The deck finish was a stone tile on mortar over a roofing membrane. However, the deck guardrail

Structural Parallam beam deteriorated.

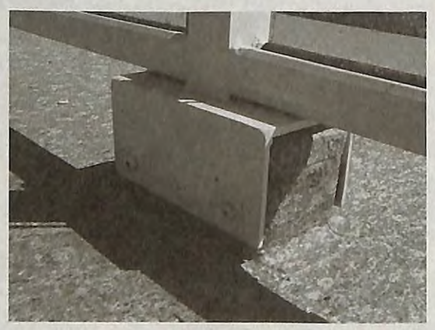
Deterioration in the roof joists in ten year old house. The spray foam insulation in this non-vented assembly was pristine and bone dry, but the wood was rotten in the upper part of the joists.

was top mounted with the post mounting plates fastened directly to the structure, penetrating the roofing membrane.

In less than ten years the water penetrating through the post bracket led to significant destruction of the framing. The images show the top of the joists after the deck sheathing had been lifted.

The moisture damage was aided by poorly executed workmanship of the deck membrane and the reverse vapour drive of surface moisture penetrating through the mortar bed, because the deck was in an exposed southern location.

Repair and remediation is going to entail considerable effort and cost that could have been avoided.



If roof deck requires post footings that are top mounted, one way is as was done in this case – the roofing membrane was wrapped around a structural block, and an inverse U bracket manufactured and mounted to the side of the block, avoiding any horizontal penetrations.

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Energy Answers

Rob Dumont

How does Canada compare with other jurisdictions in terms of electricity use per capita?

Canada is a BIG electricity user.

This April my wife and I were in California for a building energy conference. California uses about 57% less electricity per capita compared with Canada. 57% less. One of the first things I noticed upon arrival is that the San Francisco Airport is connected by rapid transit—the BART (Bay Area Rapid Transit)- to downtown. By comparison, neither Toronto (population 2.5 million) nor Montreal (population 1.6 million), both much larger cities, has a direct rapid transit connection from the airport to downtown while San Francisco (population 800,000) does. Another thing I quickly noticed about San Francisco was the absence of large right of ways for electrical transmission towers compared with many Canadian cities.

In Canada we have a fixation on energy supply. Look at the capital budget of almost any electrical utility in Canada, and the money allocated to new energy supply will greatly exceed that assigned to reducing energy demand.

And look at the dollars that have been spent on nuclear energy in Canada: "After 60 years operation and $21 billion invested, Ottawa is unloading Atomic Energy of Canada Limited CANDU business for a mere $15 million and future royalties." *Globe and Mail, June 30, 2011*

By contrast, California has a much stronger focus on reducing electricity demand. The California Energy Commisssion has the following policy in place: "The state, in meeting its energy needs, would invest first in energy efficiency and demand side resources, followed by renewable resources, and only then in conventional electricity supply." Now if only Canadian utilities would adopt the same approach.

California, with 37.3 million residents, has more people than Canada (34.3 million). Just imagine the benefits if Canada used the same amount of electricity per capita. Were Canada to improve its energy efficiency so that it matched California's rate of electricity use per capita, Canada could eliminate all nuclear power stations and all coal-fired stations in this country. (As of 2007, coal supplied 16.6% of electricity generation, and nuclear 15.5% in Canada. Hydroelectricity supplied 58.7%.)

A beneficial side effect from eliminating coal-fired power stations would be a substantial improvement in health. As quoted in the Globe and Mail of July 13, 2009, "Each year, according to the Ontario Medical Association, the province's coal plants kill 668 people while causing 1100 emergency room visits and more than 300,000 minor illnesses."

Canada's wastage of electricity has been going on for a long time. I can remember one of my uncles, who moved from Alberta to Ontario in the 1930s, commenting on how much cheaper the electricity in Ontario was at that time. (Ontario benefitted from the cheap power of the Niagara River System, while Alberta was dependent on coal-fired generation.)

What are some practical things that could be used to improve residential electricity use in Canada?

There are two main categories of residential electricity use:

1. LAME (Lights, Appliances and Miscellaneous Electricity)

The minimimum energy efficiency for white goods (clothes washers, refrigerators, freezers, and dishwashers) should be raised to the Energy Star Tier 3 rating.

Occupancy sensors should be mandatory for all consumer electronics such as TVs, DVDs, Cable boxes, routers. After 15 minutes, if no one is in the room, the electronics would automatically shut off.

Incandescent lamps should be replaced by more efficient lamps such as compact fluorescent or light emitting diode lamps. Fortunately this is being implemented in Canada.

2. SPACE HEATING

In certain provinces such as New Brunswick and Quebec, space heating using baseboards is a very large user of electricity. A practical, cost-effective approach to reduce space heating electrical consumption is to use a mini-split heat pump. Japanese companies such as Fujitsu, Daikin, Mitsubishi, and Sanyo make the units. For every unit of electricity put into the heat pump, about 3 units of space heating are provided. In figure 1 an installation of a mini-split heat pump is shown.

Recently in the northwest of the U.S.A. 12,000 of the mini-split heat pumps were installed. As space heating is often the peak load in such houses, the substitution of electric baseboard units with mini-split heat pumps can make a tremendous difference in electrical consumption. These heat pumps work best where the outdoor temperature does not go below -18˚C (0˚F). Thus they would work best in coastal areas.

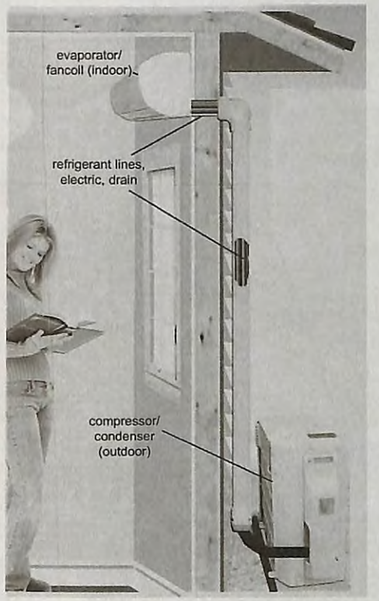


Figure 1. Minisplit heat pump showing the indoor and outdoor components. (courtesy Fujitsu)

What about non-residential electricity use?

Two technologies that have been overlooked in this country are co-generation and the use of very high efficiency motors.

Energy efficient technologies in this country have been barely tapped. We unfortunately have focused too much money and resources on increasing electricity supply.

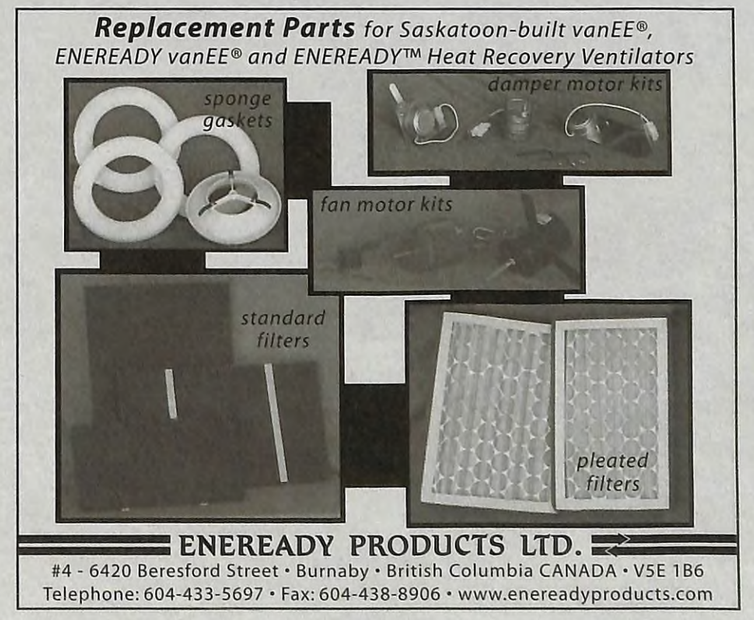
Bruce Gough: In Memorian

It is with sadness that we must report the passing of Bruce Gough on July 13, 2011 following a battle with cancer. Many readers will have known Bruce as a pioneer in residential energy efficiency and building science.

An architect by training, he was actively involved not only with leading edge building design and construction projects, but also with building codes, standards, and energy-labelling programs in the U.S. and Canada. He was an early instructor for the R-2000 program, and taught many others through builder workshops and at Carleton University's School of Architecture. He was also a member of CMHC's International Training Team that supports Canadian housing exports in foreign markets.

An Ottawa native, he worked with Minto on several innovative projects, including the Innova House (one of ten innovative Advanced houses built across Canada in 1992-93) and more recently he participated in the design of the Minto EQulibrium (Net Zero) Home in Manotick, Ontario. Bruce also drafted the original ENERGY STAR for homes design specification for NRCan and worked to adapt the US HERS rating tool for use in Canada. More recently he served as the first Chair of CRENET.

He was a frequent speaker and industry trainer, a passionate building scientist and a persuasive committee member. Those who had the pleasure of getting to know and working with Bruce will fondly remember both the man and his legacy.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Impact of Cold Climate on Basement Temperatures

by Marianne Armstrong

The analysis of 7.5 years (January 2003 to August 2010) of basement foundation temperature data from the Canadian Centre for Housing Technology (CCHT) Reference House correlated outdoor temperatures to interior foundation temperatures, and identified conditions conducive to condensation on the interior surface of the concrete foundation wall.

The basement in the Reference House has 200-mm (8-in.) poured concrete walls, full-height interior 2x4 stud walls with glass fibre batt insulation (RSI-3.4, R-19), and a 25-mm (1 in) air gap between the stud wall assembly and the concrete. A spun-bonded polyolefin (SBPO) membrane wraps the entire stud wall assembly, attached to the interior side of the concrete and also to the interior side of the stud wall. The interior of the assembly is unfinished – the SBPO membrane is exposed to the basement air. The use of the SBPO membrane on the interior was an experimental variation from conventional practice to investigate its moisture control performance.

Ground and surface temperatures were measured on the north side of the house using thermocouples at various depths on both sides of the foundation wall. The house itself faces south.

Relationship with Outdoor Temperature

Basement wall surface temperatures exhibited a strong relationship to outdoor temperature. Temperatures near soil level react quickly to changes in outdoor temperature, while temperatures at greater depths depend on outdoor temperatures over a longer period of time. On the interior of the concrete foundation wall, the surface temperature at ground level depends on the average outdoor temperature histories from the previous three days (Figure 1).

On the other hand, the concrete surface temperature near the base of the wall depends on average outdoor temperature histories over the previous 69 days. This means than on sunny days in spring, the main and second floor of a house may be warm enough to satisfy the central thermostat and shut off the heating system, while the basement surface temperatures may be at their coolest level of the year. These combined factors could contribute to a basement being uncomfortably cool at this time of year.

Temperatures on the interior surface of an insulated basement wall are generally higher than temperatures on the surface of the concrete, as they are most influenced by basement air temperature. Temperatures are coldest at the base of the wall, and warmest at the top. The gradation in temperature from the base to the top of the interior wall is likely influenced by the cooler uninsulated slab and resultant basement air temperature stratification.

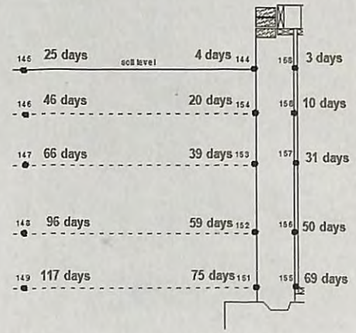

Figure 1. Temperature dependence on the average outdoor temperature over the previous x number of days

Basements with different amounts of insulation than the Reference House would have different temperature profiles. Insulating on the exterior of the foundation wall should result in warmer concrete surface temperatures, depending on the detailing at grade, and thus reduce the potential for condensation.

Similarly, different depths of basements would also result in different temperature profiles. The basement in this study had only about 30 cm (2 ft) of exposed foundation above grade. Surface temperatures in a shallower basement or a basement with more exposure above grade would likely follow outdoor conditions even more closely – cooling more rapidly in winter, and heating more rapidly in summer.

Marianne Armstrong is a research council officer in the Building Envelope and Structure Program of the NRC Institute for Research in Construction. She can be reached at marianne.armstron@nrc-cnrc.gc.ca

Effect of Snow Cover

The impact of snow on the foundation wall surface temperature is minimal compared to the relationship with outdoor temperature. Snow cover in excess of 60 cm was found to have some impact, keeping the interior surface temperature of the concrete foundation wall above freezing despite cold outdoor temperatures. However, the occurrence of this amount of snow cover was infrequent for the period studied and did not account for local effects such as drifting and melting near the foundation, so no conclusions could be drawn.

Potential for Condensation

Hourly outdoor and basement humidity levels were analyzed in detail for a one-year period to determine the risk for condensation on the interior surface of the concrete wall.

Outdoor humidity levels were generally higher than basement humidity levels in the summer months. If the outdoor air entered the basement – for example, through an open window – and came in contact with the foundation wall behind the insulation and encountered temperatures below the dew point, condensation could occur. Conditions were favourable for outdoor air to condense on the interior surface of the foundation wall behind the insulation for approximately 17% of the one-year period.

The interior surface temperature of the concrete was of interest because of the lack of air/vapour barrier on the inside surface and the air space between the stud wall assembly and the concrete wall. This construction does not prevent basement air from circulating in the wall assembly and for moist air to potentially come into contact with the cold concrete surface. While the Reference House basement performed without any observed condensation problems through the period of analysis, the house is not humidified in winter, and runs air conditioning continuously throughout the summer, leading to dryer conditions than would be typically found in a home. The lack of an air/vapour barrier could lead to moisture issues in homes with only a slightly more humid indoor environment – well within the operating humidity levels recommended by Health Canada.

The threshold may be even lower at locations where surface temperatures were not measured, such as the header area or the corners of the foundation where heat loss is usually greater. This suggests that commonly maintained humidity levels could result in condensation on the interior of the foundation wall in this type of wall assembly, which lacked the vapour barrier.

The results from this study are for a single thermostat setting, 21°C in winter. Different operating conditions would likely result in different basement surface temperatures, and different potentials for condensation.

Ramifications for Builders

This study shows that the combination of warm, humid spring/summer air and the cold surface of the concrete basement wall, due to the lasting impact of cold winter weather on ground and concrete temperatures, can lead to condensation problems. This highlights the need for a continuous air/vapour barrier on the interior of the basement insulation to prevent humid air from reaching cold foundation wall surfaces. With a proper air/vapour barrier on the interior finished wall surface to prevent interior moisture from getting in contact with the concrete, the cold temperatures of the concrete wall would not be a concern. In this situation, the interior surface temperatures of the finished wall would be the determining factor with regard to potential for condensation. ☼

Located in Ottawa, the CCHT is a partnership between Canada Mortgage and Housing Corporation, Natural Resources Canada and the National Research Council of Canada. It has been the scene of numerous studies investigating a variety of building science issues and energy-efficient technologies.

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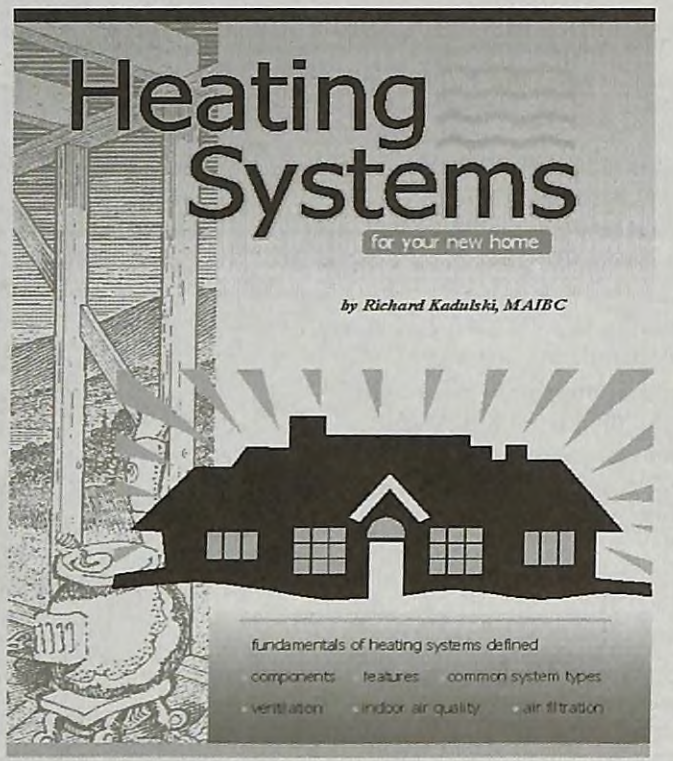

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